THE GLASS INDUSTRY
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A. C. S. HOLDS ANNUAL CONVENTION

Exceptional Program Planned for Glass Division

EYES of the industry this month are centered on the annual meeting of the American Ceramic Society, which will be held at the Hotel Statler, Buffalo, the week of February seventeenth. Thanks to the untiring efforts of a very able convention committee, the program arranged is well above even the usual high standards expected on these occasions, and all signs point to a record attendance.

A most elaborate program of plant visitations, business and technical sessions has been arranged, which include several unique and most enjoyable entertainment featues. The convention will be formally opened Sunday evening by a reception, with music by the Carborundum Band, an organization of national broadcasting prominence. The Buffalo Boadcasting Company will carry part of this concert over the air.

On Monday, the technical and business sessions are scheduled for both morning and afternoon. Monday night there is to be a big surprise party, the details of which are being guarded with much secrecy. About all the information that is being released concerning the party is its name: "The Shuffle." But the committee offers a money back guarantee that it will be the most amusing, most highly diverting and most distinctly novel of any on record.

Another high spot of the entertainment program is the annual ball on Wednesday night, for which the music will be furnished by Lloyd Huntley and his orchestra, who are the present sensation in Buffalo. A splendid floor show will be put on during the dancing.

The entire city of Buffalo is helping to make the visit of the ceramists and their guests entertaining and profitable. Stores, banks, etc., will exhibit displays of glass and pottery. At Niagara Falls, a special color illumination of the Falls has been arranged. There will be a special exhibit of "Made in New York State" ceramic products as well as educational process exhibits, and these together with a series of five radio broadcasts for two weeks prior to the convention will acquaint the citizens of Buffalo and vicinity with the products made by the guests they will be entertaining.

Women visitors will find special arrangements made for them, including bridge parties, teas, receptions, and shopping tours. A trip will be made to historical Old Fort Niagara. A day visit will be spent at Niagara Falls, whose cataracts are magnificently decked with ice and snow at this time of year. Here will be given a lecture by W. K. Bradbury on the geological history of the Falls and projects for preventing their threatened erosion. Another trip will be to the Benson collection of

Ceramists will enjoy the rare opportunity of visiting the research laboratories of the Eastman Kodak Co.—the building in the center foreground with the white roof.

Many of the operations of the manufacture and grinding of optical glass will be shown the visitors at Bausch & Lomb Optical Co., Rochester, N. Y.

early American glassware, one of the best of its kind in the country, on display at the Historical Society. And the Buffalo Pottery will be host to them on still another occasion.

The Edward Orton, Jr. Fellowship lecture, held annually under the auspices of the Fellows will be delivered by Heinrich Ries, Professor of Economic Geology at Cornell University. His subject will be "some Aspects of Clay Research."

This year the plant trips will be of more than usual interest, due in large measure to the fact that Buffalo is the most important center of hydro-electric power in the country. Other conventions have provided opportunity to inspect gas and coal centers; but here Niagara Falls has been harnessed to turn the wheels of industry for hundreds of miles of surrounding country. A visit will be made to the Niagara Power Company.

Of special interest to the Glass Division will be trips to Corning, Bausch & Lomb, Eastman Kodak, and The Carborundum Company. At Corning, the main plant of the Corning Glass Works will be open to the convention visitors as well as the Fall Brook Division where may be seen the high speed automatic production of tubing for the lamp industry.

At the Carborundum Company, the parties will be shown through the electric furnace rooms and view in detail the manufacture of this well known abrasive and refractory product. Arrangements will be made so that the whole furnace process from beginning to end will be seen and studied. For instance, some of the furnaces will be shown being loaded with the charge of coke, sand, sawdust, and salt. Others will be shown loaded and ready to burn, in the process of burning, cooling and being taken down for the removal of the finished product, the masses of the Carborundum Brand Silicon Carbide crystal. The furnaces used in the process are of the electric resistance type. They are approximately fifty feet long, eight feet wide and each takes a charge of about seventy thousand pounds of the crude mixture, which, during the furnace run of thirty-six hours, is subjected to a maximum temperature of 4,000 degrees Fahrenheit. Each furnace uses 2,000 HP. or the equivalent of 72,000 HP. hours during the thirty-six hour run, and is constructed of movable iron sidings lined with fire brick and having permanent ends or abutments through which the electrical energy is led from bus bars to cables through electrodes ten inches in diameter to a core formed through the center of the mixture of the crude materials. The electrical energy, in a sense, surges through this core, which is made up of particles of crushed graphite and coke, and the resistance set up makes possible the extremely high temperature at which this Silicon Carbide is created.

At the Bausch and Lomb Optical Company, an itinerary has been prepared covering the glass works, precision optics department, microscope assembly division, spectacle lens grinding plant, and the Panoptik bifocal lens fusing department. In addition to this tour through the manufacturing divisions, portions of the recent exhibit of instruments and optical glass shown by Bausch & Lomb at the annual meeting of the Optical Society of America at the Bureau of Standards, will also be on display. This will include fourteen different kinds of optical glass blocks prepared to show physical quality, each glass having specific optical constants controlled within close limits by ingredients in the batch. Such

instruments as the chemical microscope, for testing ring strain, the polariscope, petrographic microscope, wide-field binocular microscope, and the Abbe refractometer, all used in the ceramic industry, will be included in a general display of hundreds of scientific instruments.

In the glass plant visitors will see the mixing of the batch, melting, pouring, pressing, cutting, inspecting, and sorting of glass. The furnaces, which must be kept at a temperature of 2600 to 2700° F, and the annealing ovens are interesting features of the plant. The difference in treatment of ophthalmic and optical glass will be explained, and, if time permits, a visit to the pot making department will be made, where special pots are fashioned out of materials selected for their purity and their particular ability to withstand heat and the corrosion action of the special optical glasses.

In the precision optics department, where precision lenses and prisms are made for fine optical instruments, visitors will see the most critical inspection known to modern manufacturing methods. Surface variations are measured in millionths of an inch.

The ophthalmic lens grinding plant, with a floor capacity of about 214,000 square feet, which uses almost 2,000,000 pounds of special abrasives annually in turning out 15,000,000 lenses, is responsible for an output of 21,048 combinations of lens powers of which a minimum supply of 1,000 each must be kept in stock. The intense care given to the fusing process of Panoptik bifocals will be seen in the room into which dustproof air is supplied through a special filtering system.

In the microscope and microtome assembly departments skilled mechanics are employed in mounting eyepieces, objectives, condensers, photographic lenses, and in field glass assembly. Besides the regular assembly work, numbers of experts are employed in repairing delicate instruments received from all parts of the world.

The Bausch & Lomb visit will consume most of Friday morning and will terminate in the company's cafeteria. After lunch, the visitors will be guests of the Research Laboratories of Eastman Kodak Company. Visitors are seldom given access to these laboratories in their entirety, and it is scarcely an exaggeration to surmise that this will be the last and only occasion many of the Glass Division members will ever enjoy to inspect the work of one of the most important research laboratories in this country.

The program prepared for the Glass Division, given here in detail, covers a wide range of subjects and includes several outstanding papers. Of special interest will be number five, covering a report on work done to date on the chemical durability of glass. This project, probably the most ambitious of any research so far undertaken by the Division, was initiated last September at the Lake Keuka meeting, at which time a procedure and method of testing was decided upon. Six samples of two different kinds of glasses, three of them bottle glasses and three sheet glass, were prepared and sent to the collaborating laboratories. Each sample previously had been given a code number, so that no one would know the identity of the glass upon which he was working.

The following laboratories are collaborating in making the tests: American Optical Co., American Window Glass Co., Bailey & Sharp Co., Bausch & Lomb Optical Co., Bureau of Standards, Carr-Lowry Glass Co., Corning Glass Works, Geophysical Laboratory, Hartford-Empire Co., Hazel-Atlas Glass Co., Libbey-Owens-Ford Co., McBeth-Evans Glass Co., Maryland Glass Co., Massachusetts Institute of Technology, New York State College of Ceramics at Alfred University, Ohio State University, Owens-Illinois Glass Co., Pennsylvania State College, Pittsburgh Plate Glass Co., Purdue University, Rutgers College, Sharp-Schurtz Co., University of Illinois, University of Pittsburgh and Whitall-Tatum.

Up to the first of February, approximately one-half of the tests had been reported to the Bureau of Standards, and at Buffalo Dr. Lundell will present these results to the meeting. His paper will challenge the interest of every glass technologist; for even in this short space of time, quite definite and interesting data has been obtained.

The Convention Executive Committee is composed of the following: Dean M. E. Holmes, Alfred University, Alfred, N. Y., *chairman*; S. F. Walton, The Exolon

Members of the Glass Division will witness the operation of the electric furnaces at the huge plant of the Carborundum Company at Niagara Falls.

Program of Sessions of

American Ceramic Society's Annual Meeting

Sunday—Meetings of Trustees—Division Officers and Committees—President's Reception.
Sunday Evening Concert.

Monday, 9:30 A. M.—General Session—Kiln Firing Symposium.
2:00 P. M.—General Session—Ceramic Art Program.
4:00 P. M.—Fellows Meeting.
9:00 P. M.—The Buffalo Shuffle.

Tuesday, 9:30 A. M.—Division Meetings.
12:00 M.—General Luncheon—Committee Reports.
6:00 P. M.—Keramos Dinner.
8:00 P. M.—Edward Orton Jr. Fellowship Lecture by Dr. Heinrich Ries, Professor of Economic Geology at Cornell University.

Wednesday, 9:30 A. M.—Division Meetings.
12:00 M.—Refractory Division Luncheons.
6:30 P. M.—Student Reception and Dinner.
9:00 P. M.—Dance and Floor Show.

Thursday, 9:30 A. M.—Refractories Meeting.
9:30 A. M.—Enamel Division Meeting.
9:30 A. M.—Plant trips in Buffalo.
P. M.—Plant and scenic trip to Niagara Falls.
Dinner in Niagara Falls.
Falls illumination.

Friday—Plant Trips (time of visits to be announced at meeting).
Rochester—Bausch & Lomb Optical Co.
Eastman Kodak Co.
Erie—General Electric Co. (Enameling Division)
Corning—Corning Glass Works.

Company, vice-chairman; L. D. Walrath, Acme Shale Co., treasurer; J. Easter, The Carborundum Company, secretary; Dr. J. C. Hostetter, Corning Glass Works, member ex-officio.

Committee Heads include: L. D. Walrath, *Finance*; F. D. Bowman, The Carborundum Company, *Publicity*; D. E. Sharp, Bailey and Sharp Co., *Transportation;* Dr. R. C. Benner, The Carborundum Company, *Plant Trips;* Fred Hazelwood, Buffalo Pottery, *Ladies Entertainment;* Dean M. E. Holmes, Alfred University, *Exhibits;* S. F. Walton, The Exolon Company, *Entertainment*; G. S. Diamond, Electro Refractories, *Cooperative and Meeting Service.*

The Glass Division will meet on Tuesday morning at 9:30 and will continue on Wednesday at which sessions the following papers will be read:

GLASS DIVISION PAPERS

1. The Calculation of Physical Properties of Glasses from their Composition

By S. R. Scholes, Department of Glass Technology, New York State College of Ceramics, Alfred, N. Y.

Calculation under additive theory is criticized. Factors should represent real values for substances on which they are based; this requires postulation of compounds, which is open to question. Specific volumes must be considered, since properties are an effect of volume, not of weight. Examples from data on B_2O_3-glasses are given.

2. Viscosity and Conductivity of Soda-Potash-Silicate Glasses

By K. Lark-Horovitz and C. L. Babcock, Purdue University, Lafayette, Ind.

Using the method described previously (see Jour. Amer. Ceram. Soc., 17 [11], 329-42 (1934), the viscosity and electrical conductivity of glasses containing sodium potassium and silica have been investigated. It has been found that for all glasses containing an excess of potassium over sodium the simpler relation between conductivity λ and viscosity η,

$$\eta = A[1/\lambda]^{\beta}$$

does not hold anymore. It has been found that in this case the temperature dependency of the work function for conductivity and viscosity is not the same indicating the effect of the formation and breakup of complexes in this temperature.

3. The Hardness of Glass

By G. W. Morey, Geophysical Laboratory, Washington, D. C.

A discussion of the significance of glass hardness and methods for its measurement are given.

4. Changes in the Elastic Property of Glass as Affected by Temperature

By A. E. Badger and W. B. Silverman, University of Illinois, Urbana, Ill.

The modulus of elasticity of a soda-lime-magnesia-silica glass was determined at various temperatures up to 450°C by measurements of the elongation of a glass fiber under load. The modulus was found to decrease regularly with temperature rise except over the range 250 to 300°C where a greater rate was noted.

5. Progress Report on the Development of Methods for the Determination of the Chemical Durability of Glass

By G. E. F. Lundell, National Bureau of Standards, Washington, D. C.

A large number of laboratories are cooperating with a Committee on Chemical Durability investigating a proposed method using samples of glasses issued by the Bureau of Standards.

6. Relation of Electrical Surface Resistance of Glass to Chemical Durability

By E. M. Guyer, Corning Glass Works, Corning, N. Y.

Surface resistance measurements on a graded soda-lime-silica series of glasses and on a mixed series including borosilicates, lead glasses, lead borosilicates, and lime glasses are compared with measurements of loss of weight in water vapor made on the same glasses.

7. Investigations of Opalescent Glasses: Silicon, Sodium, Calcium, Aluminum, Oxygen, Fluorine Series

By Henry M. Blau, Victor Hicks, and Alexander Silverman, Macbeth-Evans Glass Co., Charleroi, Pa.

This paper is an extension of the previous work of the authors to opalescent glasses containing aluminum. The melting losses for a series of glasses are reported and interpreted to throw new light on the liberation of flourine from these glasses and the role of aluminum in them.

8. The Concentration of Glass as Affected by Cooling Rates

By J. T. Littleton, Corning Glass Works, Corning, N. Y.

It has been known for some time that glass cools from temperatures well above the annealing temperature contracts at a rate depending upon its cooling rate and the temperature from which its cooling begins. Expansion measurements taken on the glass during later heating do not follow the original contraction curve. A photoelastic method is described which gives information on how the contraction of the glass is affected by these temperature conditions. The observations are of particular interest when applied to glass-metal seals.

9. The Measurement of Strains in Glass Rods

By A. W. Hull, General Electric Company, Schenectady, N. Y.

Mathematical analysis has shown that when a symmetrically strained glass rod is viewed in polarized light at right angles to its axis, the only phase displacements produced are those due to the axial components of stress. This method has been applied to the analysis of stresses in glass-metal seals. It is also applicable to the quantitative determination of annealing rates.

10. X-Ray Diffraction Study of the Structure of Soda-Silica Glasses

By B. E. Warren, Massachusetts Institute of Technology, Cambridge, Mass.

X-ray diffraction patterns have been made on seven samples of soda-silica glass with soda varying from 0 to 46%. The change of pattern is perfectly continuous. The patterns can be quantitatively interpreted in terms of a random network structure. Each silicon is tetrahedrally surrounded by four oxygens. Part of the oxygens are bonded to two silicons and the others to one silicon and one or two sodiums. The patterns give no evidence for the existence of compounds.

11. Infra-Red Transmission of Glass

By E. D. Tillyer and T. M. Gunn.

Measurements of special glasses containing most of the usual elements including transmission curves throughout the infra-red are discussed.

12. Strength of Glass under Sustained Loading

By F. W. Preston, Butler, Pa.

A preliminary report on the effect of the time element on the apparent strength of glass is given. Tests have been run on bottle glass from three seconds to 30 minutes duration and on polished plate and drawn window glass (in the form of laths) from five seconds to several hours.

13. The Effect of Variable Viscosity upon Stress Release in Glass at a Constant Temperature

By H. R. Lillie, Corning Glass Works, Corning, N. Y.

An effort is made to demonstrate experimentally certain fundamental fallacies in the Adams-Williamson expression for annealing rate at constant temperature. A new expression free from these objections and taking into account the variation of viscosity with time is shown correctly to represent observed annealing rates under a larger variety of conditions than those to which the Adams-Williamson law can be applied.

14. The Peate Telescope Mirror of 1895

By F. W. Preston, Butler, Pa.

The first big telescope mirror cast in the United States was made by the Standard Plate Company at Butler, Pa., in the spring of 1895 and was figured by John Peate, Greenville, Pa., between 1895 and 1898. A brief history of the undertaking is presented.

15. History and Some Measurements of the Peate Disk

By George W. Morey, Geophysical Laboratory, Washington, D. C.

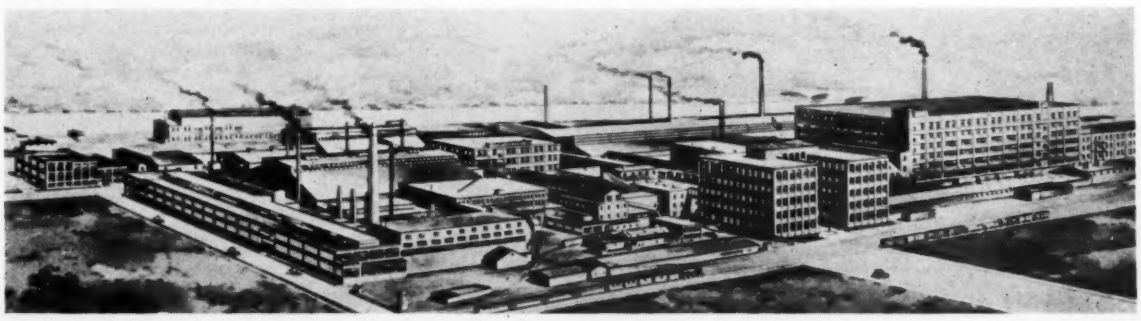
16. Some Engineering Problems Connected with the Manufacture of a 200-Inch Telescope Disk

By Geo. V. MacCauley, Corning Glass Works, Corning, N. Y.

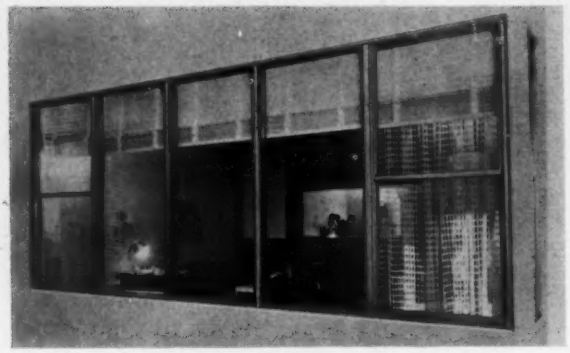
The processes of melting, ladling, casting, annealing, and crating are explained from an engineering viewpoint. Departures from usual practice in these processes brought about by the use of existing equipment, a special glass, and commercially obtainable material are discussed. Illustrated.

REFRACTORIES DIVISION PAPERS

"Reliability of Measurements of the Therma Conductivity of Refractory Brick," by J. B. Austin and R. H. H. Pierce, Jr.; "Firing Clay Refractories with By-Product Coke Oven Gas," by C. E. Bales and W. T. Christian; "Properties of Refractory Brick Suitable for Use in Glass Furnace Upper Structure," by W. L. Fabianic; "Effect of Repeated Firing upon the Specific Gravity and Microstructure of Some Aluminum Silicate Minerals," by Frank Harwood Riddle; "Young's Modulus of Elasticity at Several Temperatures for Some Refractories of Varying Silica Content," by R. A. Heindl; "Comparison of Used Silica Brick from Insulated and Uninsulated Basic Open-Hearth Roofs," by Fred A. Harvey; "Investigation of the Use of Magnesium Aluminate (Spinel) for Glassmelting Containers," by C. W. Parmelee and K. C. Lyon; "High-Grade Ohio Refractory Clays," by E. J. Bognar; "Forsterite and Other Magnesium Silicates as Refractories," by Raymond E. Birch and Fred A. Harvey; "Transformation of Aluminum Oxide from the Beta to the Alpha Form," by John Gallup; "Some Geologic and Ceramic Data on Georgia Flint Kaolin," by W. H. Vaughan and D. J. Fargason; "Spalling of Magnesite," by P. P. Budnikoff and B. J. Pines; "Effect of Fused Alumina and Boron Oxide on Plastic Fire Clays," by D. G. Moore and R. K. Hursh; "Physical and Pyrochemical Properties of Flint Kaolin," by W. H. Vaughan and D. J. Fargason; "Load Test Furnace," by J. L. Carruthers; "Kinetics of Solid Phase Reactions of Certain Carbonates with Mullite, Silica or Alumina," by G. R. Pole and Nelson W. Taylor; "Effect of Furnace Gas Pressure on the Behavior of Refractories," by S. M. Phelps and V. Cartwright; "A Graphical Method of Calculating Heat Loss Through Furnace Walls," by C. E. Weinland; "Evidence of Variation of Thermal Conductivity With Heat Flow in Silicon Carbide Refractories," by F. L. Fritsche; "Reaction-Expansion Measurements on Chromite and Allied Spinels," by J. H. Chesters and C. W. Parmelee; "The Mechanisms and Rates of Some Hetrogeneous Reactions Applicable to Ceramics. (a) Disintegration of firebrick by deposition of carbon monoxide. (b) Rate of Reduction of iron oxides. (c) Calcination of Limestone," by C. C. Furnas; "Solid Reactions Between Ni, Fe, Cr, Mn, and Their Oxides with MgO and BeO between 1000° C and 1200° C," by Louis Navias; "Liquid Air," by A. E. Harding; "The Glassy Phase in the Manufacture and Use of Refractories," by George W. Morey; "The Problems Encountered in Air Cooling and Water Cooling in Glass Tank Walls," by L. T. Sherwood; "Kyanite in Crucibles for Melting Glass," by S. R. Scholes; "Advanced and Refined Technique in the Petrographic Study of Crystalline Refractories," by R. B. McCormick; "Determination of Alkalis in Silicates with Special Reference to High Alumina Refractories," by E. B. Read.



The high speed production of glass tubing for the lamp industry is an item of more than ordinary interest at the Corning Glass Works.



DESIGNS NEW WINDOW

An advanced type of weight-hung window, made of aluminum and designed in simple, striking lines for wide residential use is arousing widespread interest on the part of the general public as well as architects, builders, and designers, because of its remarkably easy action, distinctive beauty, and compact construction. Moreover it may be produced so economically that it will be suitable for medium or low-cost houses.

Sash, frame, and weights are built into one unit, glazed and ready for quick installation. Wide mullions, hitherto considered unavoidable between double-hung windows, are reduced from approximately 5½ inches to 1 inch. These narrow mullions, together with narrow sash members and frames, admit more daylight for any given window size than does ordinary construction.

Many unique advantages are claimed for the new window by its makers, The Kawneer Company, of Niles, Michigan, which holds patents on the design and construction. Shrinking, swelling, warping, rattling, rusting, and rotting out have been eliminated, and thus the causes of most window difficulties removed. The solid aluminum sash and frame members withstand the elements indefinitely without further protection or renewal. Upkeep and maintenance expense have been reduced to an absolute minimum if not altogether done away with. Although sash may always be operated with surprisingly slight effort, they fit snugly against the frame, slide on integral weatherstrip guides, and effectively keep out rain, snow, wind, or dust.

Because of its simplicity of construction and design this new window harmonizes with the most modern domestic architecture, as well as with all conventional styles.

NEW FRIT IS ANNOUNCED

The O. Hommel Company, Pittsburgh, Pa., announces a new Hommel Frit, No. 640, that is super-opaque, and can be applied in relatively thick layers without any difficulty.

SHIP 3-TON MIRROR

An unusual shipment recently was made from the Corning Glass Works, Corning, N. Y., when a 3-ton mirror was sent to the Warner & Swasey Co., Cleveland, Ohio, where it will be ground to the exact mathematical curve required for a new telescope for the McDonald Observatory, Texas, to be furnished by the last noted company. The new mirror when finished, estimated to require over a year, will be about 81½ inches in diameter.

PITTSBURGH PLATE GLASS EXPANDS

It is reported that plans have been approved by the Pittsburgh Plate Glass Company, Pittsburgh, Pa., for the expansion and improvements in its branch plant at Henryetta, Okla., which will include the construction of new additions and the installation of equipment. Increased production facilities and efficiency in operations form a portion of the program which will include new cutting rooms, extensions in the annealing division, and the rebuilding of two tanks. New storage and distributing space also will be provided, increasing present warehouse space by about 40 per cent. The entire program will cost upwards of $250,000.

W. J. D. WALKER JOINS CORNING

Walter J. D. Walker, formerly of the faculty of Washington University, St. Louis, Mo., has joined the sales department of the Corning Glass Works, Corning, N. Y. He will have charge of the Laboratory and Pharmaceutical Sales Division left vacant by William T. Levitt.

Since 1930 Mr. Walker has been employed in the Washington University under a Rockefeller grant known as the Science Research fund. He specialized in glass apparatus and gave courses in the university on this subject. He also has done special work for a number of industrial concerns.

MR. BACON REVIEWS GLASS HISTORY

Glass making through 100 years was discussed by Lawrence Bacon, of the Whitall Tatum Co., Millville, N. J., before the Bridgeton Kiwanians on January 10. A three-reel movie was shown covering the manufacture of glass in the Whitall Tatum plant and the history of glass manufacture as it has been carried on continuously in Cumberland County for 99 years. His company will celebrate its 100th anniversary next year.

W. S. RENDALL MANAGES DIAMOND GLASS

W. S. Rendall, until recently head of the Economics Research Department of the Hartford-Empire Company, is now manager of the Diamond Glass Company, Royersford, Pa., which concern is now in the process of reorganization. Mr. Rendall, who, in the past, has had the opportunity of contacting many glass concerns, is a confirmed believer in the future of the relatively small or medium size concern.

EDWARD MILLER RECOVERS

Edward Miller, former owner of the Miller Machine & Mold Works, Columbus, O., returned to his home on January 9 from Milliard Filmore Hospital where he has been a patient. Having fully recovered from an operation, Mr. Miller plans to spend the remainder of the winter in Florida.

WANT SAFETY GLASS IN SCHOOL BUSES

It is reported that a bill is being introduced into the North Carolina State Senate requiring that the 4,250 school buses now in use be equipped with non-shatterable glass in all windows and that the bus bodies be all steel. This action, should it become law, will cost the state approximately $3,000,000 to add this safety feature.

COLOR FORMATION IN GLASSES AND GLAZES

By F. H. NORTON[1]

Abstract. The subject of color formation is reviewed in order to bring together the modern ideas of the ceramist, the physicist and the chemist. A bibliography of the important literature is given.

IT IS unnecessary to stress the importance of the production and the control of color in the ceramic industry. Yet most branches of the industry are still working by empiracal methods, and little appreciation is had of the fundamentals of the subject. Within the last few years a great advance has been made in the understanding of the problem. While there are still many puzzling questions left to be answered, it is possible to present a fairly clear picture of color production. With the help of X-ray analysis and petrography we should be able to come to a still better understanding of this subject in the near future.

Methods of Color Formation

Confining ourselves to ceramic colors, there are four principal methods of production.

The first and most common is by solution colors, produced by the colored ions of a transition element; for example, a cobalt glass.

The second method consists in forming colored crystals in the glass or glaze. These crystals usually contain atoms of a transition element. An example of this class is the red chrome glazes.

The third method produces color by selective light scattering in a colloid dispersed throughout a transparent glass. Gold ruby glass is an excellent example.

The fourth method consists in the production of a chromophore from the second atomic class. These colors are quite analogous to the organic dyes. An example is the Se-CdS red.

All but the first class are definitely influenced by heat treatment.

The Physics of Color and Its Measurement

Before considering the production of color in detail it would perhaps be well to review some of the basic principles of optics. Light consists of vibrations of the ether of definite wave lengths in every way similar to radio waves except that they are very much shorter. Daylight consists of waves of a large range of frequencies; but the eye is sensitive to only a limited range which we call the visible region of the spectrum. If any single wave length in this region is isolated by refraction or absorption, a color is produced. The wave lengths of the spectral colors are given below:

Hue	*Wave length*
Red	-620 milli-microns[2]
Orange	620-592 " "
Yellow	592-578 " "
Green	578-500 " "
Blue	500-450 " "
Violet	450- " "

The normal eye is not equally sensitive to all regions of the visible spectrum; the greatest sensitivity occurring in the yellow-green. This is the reason deep reds or blues appear less brilliant than greens and yellows.

Color can be roughly measured by comparison with a known standard, but this method gives no detailed information and is influenced by the illuminant and the observer. The most satisfactory measurement consists in splitting the light up with a prism into its component wave lengths, and then by means of a photometer measuring the intensity of each one. Curves of this type are shown in Fig. 1. It should be remembered that this is the physical color and must be corrected for the sensitivity of the eye to represent the appearance.

Any color can be represented by three attributes: dominant wave length; purity; and brightness, or reflecting power. These attributes can be calculated from curves such as are shown in Fig. 1.

The Atomic Structure and Color

THE atom is believed to be made up of a positive nucleus around which spin negative electrons in one or more shells. There are four general classes of atoms as shown below:

Class 1. Atoms with all shells completely filled. These atoms form no compounds and produce no color. Gases such as helium and neon are examples.

Class 2. Atoms with one shell (the outer) incomplete. These atoms form compounds but no colored salts. Examples are barium and tin.

Class 3. Atoms with two incomplete shells (the transition elements). These atoms have colored ions and generally show strong absorption in the visible spectrum. Iron and cobalt are examples.

Class 4. Atoms with three incomplete shells (the rare earths). These atoms give sharp band spectra in the visible region.

An atom or an ion (an atom with one or more electrons missing) can absorb light energy in two ways: first, by a vibration of the atom as a whole which absorbs in the infra-red region; and secondly by a jump of an electron from one shell to another which absorbs in the visible region. It is the latter method of absorption which interests us here. Only the transition elements and the rare earths can absorb in this way because more than one incomplete shell is required.

Elements in the vapor state give sharp absorption bands because each atom is free from the influence of others and can vibrate at its own frequency. In crystals or solutions the atoms are influenced by their neighbors so that a broader band results due to attractive forces on the electrons in the outer shell. The reason for the rare earth elements giving sharp bands even in solution is due to the fact that energy is absorbed not by electrons in the outer shell, but by those of inner shells protected from outside forces. For the same reason the color of rare earth salts and solutions is not influenced by chemical combinations.

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[1]Assistant Prof. of Ceramics, Mass. Inst. of Tech.

[2]A milli-micron equals a millionth of a millimeter.

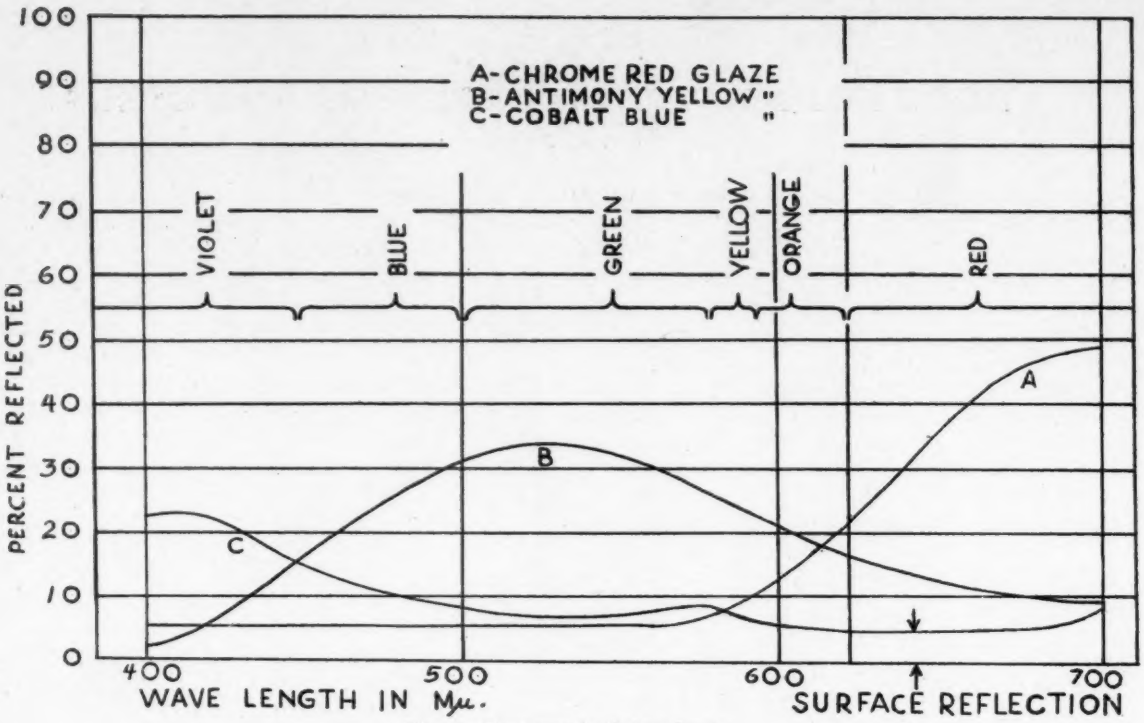


Fig. 1. Photometric Color Curves.

The amount of absorption depends on the number of active atoms or ions in the light path. This relation is expressed by Beer's Law:

$$I = I_0 \cdot 10^{-aCd}$$

Where
I=final intensity
I=original intensity
C=concentration
d=layer thickness, and
a=constant

This law does not hold for concentrated solutions.

It should be pointed out that at present the physicist can do little to calculate quantitatively the energy absorption of atoms or ions in the solid or liquid state due to the uncertain influence of neighboring groups. However, Brode[127] has pointed out the periodic character of the resolved absorption spectra in glass, and it is not impossible that we may arrive at a quantitative theory in the future.

Color and the Periodic System

The structure of the atoms can be illustrated by Table I.* The completed shells are shown on the left and the incomplete ones on the top. For example, Ni would have electrons distributed as 2, 8, 16, 2; while Ce would have a distribution of 2, 8, 18, 19, 9, 2.

The heavy vertical lines divide the elements into four classes of atoms of which the third group, or transition elements, are of the greatest interest for ceramic colors. To repeat, these latter elements produce colors by selective absorption in the visible spectrum because of energy absorption when an electron jumps from the outer to the next shell. As yet we are unable to relate the position or magnitude of the absorption band with the atomic properties. Some of these elements absorb strongly as Co and Pt, but others give only faint colors as Ag and Zr. In general, however, experiment has shown that all these elements actually give color in glasses.[121]

Group four, or the rare earth elements, all give sharp absorption bands in the visible region in solution and in glasses. Few, if any of them, give bright colors because the absorption is quite well distributed. Their only commercial importance is for some special optical glasses.

Elements of group two give no (simple) colored salts, but we do find many of these elements producing color, often very brilliant colors. There are, for example, organic dyes with C and N, and glass with Cd and Se. As the structure of the atom will not permit absorption in the visible region we must explain the color by means of a chromophore group which is able to vibrate at the proper energy level. An example of such a group is shown by:

where R is a radicle of such large volume that it is able to force out one of the normal four. The energy absorbed in this change is sufficient to produce color. The color produced by Cd and Hg salts is believed to be somewhat analogous to these.

Color Modifiers

It is a well known fact that a color produced by a transition element is not invariable in different solutes or glasses. This condition is to be expected because the vibration rate of the electrons are influenced by the

*This table is a modification of that suggested by Roy Gardner in Nature, Jan. 25, 1930.

surrounding groups. The question of color modifiers is one of great interest to the ceramic industry as it explains many of the variations met with in practice.

For example, a series of glazes was recently made up in our laboratory with 0.1 Eq of copper as a colorant and a variation in the (Na, K)/PbO ratio comprising the RO group. The dominant wave length as shown in Fig. 2 increases with the PbO content. That is, the high atomic weight of the Pb atom, by indirect influence decreases the vibration rate of the electrons in the Cu atom and shifts the color to longer wave lengths. As these measurements were made on glazes, it cannot be said with certainty whether or not the shift is due to a movement of the absorption curve or to a change in relative intensity of two peaks.

A similar condition exists in cobalt glasses as the ratio of Na_2O to B_2O_3 is varied.[127] The glasses high in B_2O_3 are pink, and have the same bands as cobaltous salt solutions, indicating lack of coordination between the B_2O_3 and the cobalt atom. As the Na_2O content is increased the color changes to blue by an extinction of one of the bands. This indicates that there is some coordination between the cobalt atom and the alkali complex, but the alkali atom itself is not directly connected because the band positions are unchanged by substitution of other alkali metals for sodium.

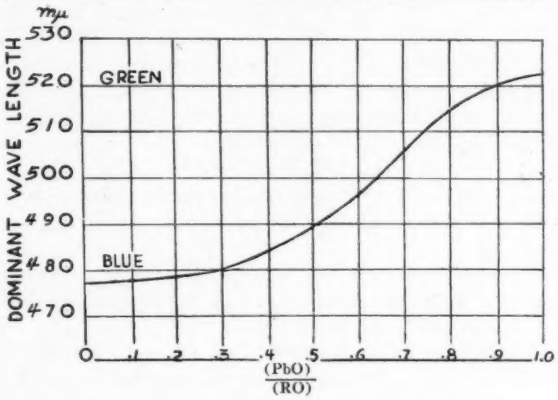


Fig. 2. Influence of base composition in color.

The state of oxidation of the coloring ion also has an influence on the color. Weyl[137] has produced Mn glasses, for example, by melting under various pressures of oxygen to produce all ratios of $MnO—Mn_2O_3$. The relative values of the absorption peaks are changed giving color variations from pink to purple. This color change can also be used to determine the state of oxidation in commercial glasses. Here the oxygen atom is believed to be directly coordinated with Mn atom to form the chromophore group. Other glasses show color changes with the state of oxidation, such as chromium.[137]

Examples of color modification are numerous in ceramics where a change in the base composition alters the color, sometimes slightly, but often to a considerable extent. In every case this modification must be due to some change in the chromophore group as explained in the previous examples. We still know very little about these modifying factors, and much experimental and theoretical work must be carried out before we can form a logical picture.

Influence of Temperature on Color

It is a well known fact that a change in temperature will alter the color of a glass or glaze. This is shown, for example, by the work of Gibbs[14], Luckiesh[21], Gibson[20], Jones[18] and Hartley[17]. Certain pink cobalt glasses will turn blue at higher temperatures. Perhaps one of

TABLE I. CLASSIFICATION OF ATOMS ACCORDING TO STRUCTURE

Complete shells	0	1	2	3	4	5	6	7	9 2	10 2	11 2	12 2	13 2	14 2	15 2	16 2	17 2	18 9 2	19 9 2	20 9 2	21 9 2	22 9 2	23 9 2	24 9 2	25 9 2	26 9 2	27 9 2	28 9 2	29 9 2	30 9 2	31 9 2
K L M N O P		H																												
2	He	Li	Be	B	C	N	O	F																							
2 8	Ne	Na	Mg	Al	Si	P	S	Cl																							
2 8 8	A	K	Ca						Sc	Ti	V	Cr*	Mn	Fe	Co	Ni	Cu														
2 8 18			Zn	Ga	Ge	As	Se	Br																							
2 8 18 8	K	Rb	Sr						Yt	Zr	Cb*	Mo*	Ma*	Ru*	Rh*	Pd*	Ag*														
2 8 18			Cd	In	Sn	Sb	Te	I																							
2 8 18 18 8	Ce	Cs	Ba						Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au*	Lu	Ce	Pr	Nd	Ie	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tu	Yb
2 8 18																															
2 8 18 32			Hg	Tl	Pb	Bi	Po	–																							
2 8 18 32 18		–	Ra																												
2 8 18 32 18 8	Rn																														
2 8 18 32 18									Ac	Th*	Pa	U																			

All shells complete
No compounds
No absorption in visible spectrum

One shell incomplete

No absorption in visible spectrum

Two shells incomplete

Variable Valance

Broad band absorption in visible spectrum

(Transition Elements)

Three incomplete shells

Sharp band absorption in visible spectrum

(Rare Earth Elements)

* Elements in which the normal atom is believed to have one electron in the outer shell

the most distinct changes is the case of a copper blue glaze which changes to green on heating. The change in hue and the glaze composition is shown in the following table:

.25 PbO
.40 K_2O .15 Al_2O_3 2.3 SiO_2
.25 Na_2O
.10 CuO

Temp.	*Hue*
20°C.	478 mμ
290°C.	480 "
380°C.	485 "
440°C.	495 "
480°C.	508 "
550°C.	525 "

It is interesting to note that the change in hue is not proportional to the temperature, as very little alteration occurs before 300°C. We do not know just what is the mechanism of the color change with variation in temperature; but it probably frees electrons due to the thermal agitation, and increases the chance of new groups forming to make up the chromophore. The color change with temperature does not have, as yet, any great industrial importance.

Influence of Light and Other Radiations on Color

Many writers have called attention to the fact that radiations not only in the visible region but also in the ultra-violet would influence the color of glasses. Hoffman[104] in a recent paper explains the coloring action to liberated electrons which may change the state of oxidation or produce colloidal colors. Schmidt[120] determined the coloring effect of X-rays on a number of glasses. Glasses of high atomic weight showed less discoloration than others.

An interesting property of nearly all glass colored by radiation is that they return immediately to the original condition on moderate heating.

Colloidal Colors

COLLOIDAL colors were recognized in solutions as early as 1857 by Faraday. Gold was the most readily prepared metal and has been used to the greatest extent. Silver, platinum, and copper will also form colloids. The feature that distinguishes colloidal colors in glass from solution colors is the marked influence of heat treatment on the former.

The colloidal particles were supposed to be small spheres of metal dispersed in the medium. At present it is thought that the particles are crystallites containing a comparatively small number of molecules. The size of the particles vary with the metal and the heat treatment, but may average about 10-100 milli-microns. The light absorption depends on the particle size, the smaller particles absorbing in the blue end of the spectrum and the larger in the red end.

It should be kept in mind that true colloidal glasses are colored by scattering of certain wave lengths from the particles and not by the color of the particles themselves. From the optical point of view there has been considerable work done on the theory of colloidal absorption. The papers of Garnett[11], Mie[12], and Gans[16] should be consulted.

As previously stated gold is the best known colloidal color, but many others have been used. It is often difficult to determine when a color is colloidal or not, but recently the X-ray has proved a powerful tool in this study. For example, Rooksby[110] has shown that the CdS-Se red glass are formed by small particles composed of a solid solution of cadmium sulphide and cadmium selinide. He concluded that perhaps only a small portion of the color was colloidal, the remainder being due to the color of the crystals themselves. This seems probable because the color of the glass varies with the ratio of CdS to CdSe in the same way as for pigments. Also the particle size had little influence on the color.

Rooksby also showed that both copper and gold ruby glasses were colored by metallic particles below microscopic size. This refutes the opinion of some investigators that copper colors are due to copper oxide particles.

Crystal Colors

MANY glazes and some glasses are colored by crystals embedded in a transparent base. Many colored crystalline glazes are familiar, as nearly all of the transition elements will produce colored crystals if the base glass is over-saturated. Red glazes colored by crystals of lead dicromate are well-known. Other crystals can dissolve coloring elements in solid solution and thus give interesting hues. Zinc and titanium crystal glazes are an example.

Jackson[64] presents an interesting discussion of crystal colors. He mentions the ancient Egyptian scarlet glass colored by small crystals of cuprous oxide.

The copper red glazes have always presented a fascinating problem to the ceramist. The same glaze can be made to give red, purple, blue, white and black according to the firing conditions. There is still much petrographic and X-ray work to be done on these glazes before we can obtain a complete picture of the color formation. However, the color is undoubtedly caused by small crystals of copper and its oxides.

The preceding are only a few of the numerous examples of crystal colors. Much work remains to be done in this fascinating field.

Summary: Colors in glasses and glazes are formed in four general ways:

1. Solution of the transition elements in a clear base producing colored atoms or ions.
2. Production of colored crystals in a base glass; usually from the transition elements.
3. Production of a chromophore from elements of the second atomic group analogous to organic colors.
4. A finely dispersed metal of colloidal size.

PLATE GLASS PRODUCTION FOR DECEMBER

The total production of Polished Plate Glass by the member companies of the Plate Glass Manufacturers of America for the month of December, 1934, was 7,922,364 sq. ft., as compared to 6,587,366 sq. ft. produced by the same companies in the preceding month, November, 1934, and 6,346,645 sq. ft. produced in the corresponding month last year, December, 1933.

This makes a total of 91,340,608 sq. ft. produced by these companies during the year 1934, as compared to a total production of 86,037,805 sq. ft. for the year 1933.

THE USE OF ARSENIC IN GLASS BATCHES

IN SPITE of the fact that numerous papers have been written on the subject of the action of arsenic (arsenious oxide) in glass batches many practical glass men still possess erroneous ideas concerning its properties and uses and consequently use it as a remedy for defects that it cannot cure or else they misuse its beneficial properties.

While the use of arsenic as a constituent of glass batches has been common practice for more than a century its action was little understood or misinterpreted, and only in recent years, through the investigations of the University of Sheffield in England; Scholes, Allen, Zies and others in America, has its true action been clearly understood.

Arsenic has been used in glass for three reasons: first, its effect as a refining agent; second, its effect on the coloration of the glass, third, for the production of opalescence. How well arsenic answers these requirements may be best shown by quoting the opinions of various workers.

As to the value of arsenic as a fining agent, E. Tscheuschner[1] (1885) expressed the view that arsenious oxide became reduced in the glass to elementary arsenic which then volatilized and thus stirred the glass and aided in the refining. J. Henriveaux[2] (1897) stated that arsenic was beneficial in glass batches as it assisted the melting of the glass but that he personally preferred to use sodium arsenate instead of arsenious acid. O. Schott[3] (1902) stated that in plate and sheet glass or in any glass made without oxidizing agents, the arsenic was driven off as a vapor, but in batches melted in the presence of an oxidizing agent the arsenic was retained in the glass as the arsenate. R. Dralle[4] (1911) supported the views of Tscheuschner.

The above views were universally adopted and believed true until the work of F. Gelstharp[5] (1912); S. R. Scholes[6] (1913); Allen and Zies[7] (1918) showed that the value of arsenic for refining the glass was questionable. The results of these investigators proved that only a small amount of the arsenic added was expelled as a vapor and that the majority of the arsenic was retained in the glass as the trioxide or pentoxide. As a further check upon this new view, W. E. S. Turner and his collaborators[8] (1922 to 1927) from the results of a series of investigations on the use of arsenic concluded that in soda lime glasses the arsenic is converted from the trivalent to the pentavalent state; that it has no stirring action when introduced with the glass batch; and that it does not act as a flux unless used in large quantities. In the case of potash lead glasses they found that the progressive addition of arsenic did speed up the melting.

There is some evidence however that shows that there may be a slight refining action when arsenic is used in the presence of an oxidizing agent. Under these conditions there are indications that the arsenic is oxidized at fairly low temperatures to the pentoxide and that as higher temperatures are reached the pentoxide dissociates into oxygen and arsenic trioxide both of which may assist in the refining. The positive evidence and resulting action are both so slight that the use of arsenic in the batch for the sole purpose of refining is not to be recommended.

Arsenic may be used as a fining agent however when a seedy pot of glass is cleared up by the method of "blocking". Its action in this case is purely mechanical and a potato, block of wet wood or a green pole would serve equally well and involves less expense. When arsenic is used for the purpose of "blocking" all of it volatilizes and none is left in the glass.

The effect of arsenic on the coloration of glass is its most useful and important property. Its action as a chemical type decolorizer having been known for some time and with more certainty than its action as a refining agent. Tscheuschner[1] (1885) advocated its use for correcting the color due to over decolorization when manganese dioxide is used as the decolorizer. Dralle[4] (1911) also confirmed this action in addition to the effect of arsenic in correcting over decolorization due to selenium. Turner and his collaborators[8] state that arsenic corrects the excess color due to manganese dioxide or selenium in addition to exerting a decolorizing action of its own in as much as it converts the ferrous ion to ferric ion. This oxidizing effect is such that the green color due to the iron in the ferrous state is converted to the less intense yellow coloration of iron in the ferric state. They also feel that the use of niter along with the arsenic will produce much more satisfactory results.

AS WAS shown in the discussion of the possible refining action of arsenic there is an indication that it acts as a reducing agent at low temperatures but at high temperatures it appears that dissociation takes place and oxygen is released. As the presence of carbonaceous materials in the batch will color glass amber or yellow, any material, such as an oxidizing agent, that will convert the carbon to a gas which will be liberated from the melt, will prevent this coloration. The oxygen liberated through the dissociation may act in this manner.

The amount of arsenic necessary for tank-flint glass depends of course upon several factors, such as the amount of iron in the glass; the type and amount of decolorizer, and, the absence or presence of oxidizing agents in the batch. The amount of arsenic when selenium is the decolorizer should not be less than thirty times the amount of selenium added and the amount may be advantageously increased above this proportion, Turner and his collaborators considering it safe to use up to 2 parts of arsenic per thousand of sand. In the case of potash lead glasses where arsenic is known to speed up refining and melting five parts of arsenic to a thousand of sand may be used.

The use of arsenic in glass for lamp-working purposes such as cane or tubing is not to be recommended as it is

[1] Tscheuschner, "Handbuch der Glasfabrikation", Leipzig, 1885.
[2] Henriveaux, La Verre et la Crystals, 397, 1897.
[3] H. Hovestadt, "Jena Glass and its Scientific and In-dustrial Applications". Translation by J. S. and A. Everett, London, (1902).
[4] Dralle, Die Glasfabrikation 1, 186, (1911).
[5] Gelstharp, J. Ind. Eng. Chem., 4, 6, (1912).
[6] Scholes, Trans. Am. Ceram. Soc., 15, 505, (1913)
[7] Allen and Zies, J. Am. Ceram. Soc., 1, 787, (1918)
[8] Turner, J. Soc. Glass Tech. 6, 169, (1922); 7, 309, (1923), 9, 111 (1925); 10, 3, 20 (1926); 11, 65, 190, 205, (1927).

liable to produce a discoloration when the glass is reheated and flame worked. Excess of arsenic, that is over 3 per cent especially in glasses containing little alumina, may cause opalescence if the glass is slowly cooled. Arsenic is also used as a component of opal glasses, particularly those of the phosphate type.

Due to the oxidizing action of arsenic and its lack of refining action there is no advantage of using it as a constituent of colored glasses such as amber or iron greens. In the case of green tint glasses colored with iron its decolorizing action may be harmful. With colors that develop best under oxidizing conditions its use may be of some benefit but with colors that are stable under either reducing or oxidizing conditions it use is unnecessary.

GLASS CONTAINER FASTENS NAME "BOOZE" TO WHISKEY

The glass industry came in for a well deserved shaft of limelight last month when the National Broadcasting Company, through its desire to cooperate with the Federal Housing Administration as expressed in the National Housing Act, broadcast the "Romance of Glass" from a dramatization by George Ludlam of the highlights of the history of glass manufacture. It was one of a series of radio presentations on the structural materials used in small house construction.

The colorful incidents in the history of glass were selected ranging from its discovery, as related by Pliny, by Phoenician sailors cooking their lunch on the sandy shore, to the present days developments in the art. Unable to find supports for their kettles over the fire these men of the sea brought chunks of natron from their cargo which they placed around the fire. When they packed up to leave they found a shiny brittle substance formed by some of the chemical melting and uniting with silicon, stated by Pliny to have been a crude form of glass.

From this more or less mythical account of the discovery of glass the narrator touched on the making of malleable glass which cost its discoverer his head because Caesar feared the loss of the value of his gold. The making of plate glass by Shevart in Paris sounded the knell of Venice as the center of glass manufacture.

In our own country the manufacture of glass log cabins by the Whitney Glass Works, of New Jersey, for Old Cabin whiskey distilled by E. C. Booz of Philadelphia was responsible for the coining of a new name for the amber liquor. They were brought out at the time Harrison and Tyler were making their "log cabin" campaign for the Presidency and vice presidency. The whiskey was poured from the cabin chimney. Because the cabins were put out by Booz the contents popularly became known as "booze" which has stuck to it ever since. While the candidates had nothing to do with the advent of the log cabins they did help to popularize the log cabin campaign.

The design of the milk bottle by Dr. Thatcher also was heralded. From the making of a dozen or two by the Thatcher Manufacturing Co., Elmira, N. Y., for a dairyman who had a route in Ogdensburg this activity has grown until now there are about 200,000,000 in use in the country.

The march of glass through the ages closed by focusing attention on the use of mirrors to bring light to the dark corners of the home; the use of plate glass in skyscrapers; bullet proof glass in banks; shatter proof glass in the automobile and the many different lenses.

"Imagine yourself in a world without glass!" said the narrator. "No cameras, no radio, no electric light, no spectacles, and above all no windows."

It would be a pretty lightless, sightless world, we fear, and today it is pretty difficult to imagine.

CHARLES FERGUS BINNS

In the death of Charles Fergus Binns, director emeritus of the New York State College of Ceramics, Alfred University, Alfred, N. Y., the ceramic industry loses one of its patriarchs. Born in England he was apprenticed to the Worcester Porcelain Works during which time he studied science and drawing. Coming to America in 1897 he directed a technical and art school in Trenton, N. J. When the state school of clayworking and ceramics was started at Alfred, N. Y., in 1900 he was chosen as director. He was a charter member of the American Ceramic Society and held a number of offices in the organization, being elected president in 1901. He contributed "The Story of the Potter," a history of pottery from primitive ware to modern porcelain, and "The Potter's Craft," a guide for the craftsman and teacher, to the literature of ceramics. The first honorary degree ever to be presented to a member of the faculty by Alfred University was awarded to him. The alumni of the school have established an annual award known as the Binns Medal to be given for excellence in ceramic art.

BOOKS AND GLASS SHOWN

Books elbowed glass out of the spotlight in its own home, the show window of the Steuben Glass, Inc., 748 Fifth Ave., New York, the artistic child of the Corning Glass Works. These tomes told of the fine works of art in glass and were opened to engravings of antique pieces made in England, France and Germany which were to be compared with a few pieces of Steuben Glass also displayed. The second floor of the galleries is being rebuilt. The library here will be available to all victims of Crystalomania sometime after the middle of February.

FEDERAL GLASS OPENS OWN BRANCH OFFICES

The Federal Glass Company, Columbus, Ohio, has opened branch sales offices at both New York and Chicago. Herbert D. Dewar, who has represented Federal exclusively as Selling Agent in New York for many years, and U. L. Conway similiarly, in Chicago, have been placed in charge of their respective branches as Assistant Vice Presidents, with enlarged selling organizations. There is no change in location of the sample rooms. These are at 1107 Broadway, New York, and Merchandise Mart, Chicago.

Glass Plant Reopens

The Bell Bernon plant of the American Window Glass Company has resumed operations after having been closed since March, 1934. It employs about 500 men.

LIBERATION OF FLUORINE IN FLUORIDE GLASS MANUFACTURE[1]

By H. H. BLAU and A. SILVERMAN

A REVIEW of the literature on the liberation of fluorine during the formation of glasses, glazes and enamels revealed many inconsistencies concerning its behavior. In an effort to clarify this situation a detailed investigation was made in which the experimental work was carried out under well-controlled and predetermined conditions.

A series of fluoride glass batches were made up from chemically pure, analyzed raw materials, dried and melted in platinum receptacles. The loss of weight, both on drying and after melting was determined and compared with the theoretical loss.

After melting, the samples were analyzed for silica, calcium oxide, sodium oxide, and fluorine by means of the Hoffman and Lundell modification of the Berzelius method. Spectographic analyses were also made and revealed the presence of small amounts of lithium and magnesium and traces of aluminum, iron, chromium and titanium. Table 1 gives the analytical data obtained.

TABLE I

Glass	Constituents	Percentages by Analysis	Compn. Calcd. From Batch	Amounts of Constituents Retained in Glass	Amts. Lost in Melting	Losses in Equivalents of F	Percentages of Each Constituent Lost
A2	SiO_2	74.1	100.0	99.1	0.9	1.1	0.9
	Na_2O	14.5	20.5	19.3	1.2	0.7	5.9
	CaO	10.0	14.1	13.3	0.8	0.5	5.7
	F	2.6	11.8	3.5	8.3	..	70.4
				Unaccounted F		6.0	50.9
B1	SiO_2	74.2	100.0	99.6	0.4	0.5	0.4
	Na_2O	14.2	20.5	19.1	1.4	0.9	6.8
	CaO	10.4	14.1	14.0	0.1	0.1	0.7
	F	2.1	9.6	2.8	6.8	..	70.9
				Unaccounted F		5.3	55.2
B2	SiO_2	74.2	100.0	99.3	0.7	0.9	0.7
	Na_2O	13.9	20.5	18.6	1.9	1.2	9.3
	CaO	10.4	14.1	13.9	0.2	0.1	1.4
	F	2.7	12.1	3.6	8.5	..	70.2
				Unaccounted F		6.3	52.0

From an analysis of these results and a discussion of the probably chemical reactions involved it was concluded that:

1. Relatively small percentages of the total fluorine are evolved as silicon tetrafluoride, sodium fluoride, or calcium fluoride from fluoride glasses.
2. Appreciable amounts of calcium are lost, particularly when the fluorine is introduced as calcium fluoride.
3. The loss of fluorine is almost a constant percentage of the amounts of fluorine introduced in the batches investigated, irrespective of its introduction as sodium fluoride or calcium fluoride.
4. Most of the fluorine loss may be attributed to its liberation from the melt in the elemental form, as the oxide of fluorine, or as a hydrogen fluoride.

[1]Abstracted from Ind. Eng. Chem., Vol. 26, No. 10, p. 1060-1062, 1934.

G. P. MacNICHOL LAUDS GLASS PROGRESS

In a talk broadcast January 10 by the Columbia Broadcasting System, G. P. MacNichol, Jr., vice president in charge of sales of Libbey-Owens-Ford Glass Co., Toledo, O., painted a pleasing picture of the future for shatter proof glass. From statistics compiled at the Automobile Show and from manufacturers' specifications for their 1935 models showed that more than 70 per cent of all new cars will be delivered this year with safety glass in the windows as well as the windshields.

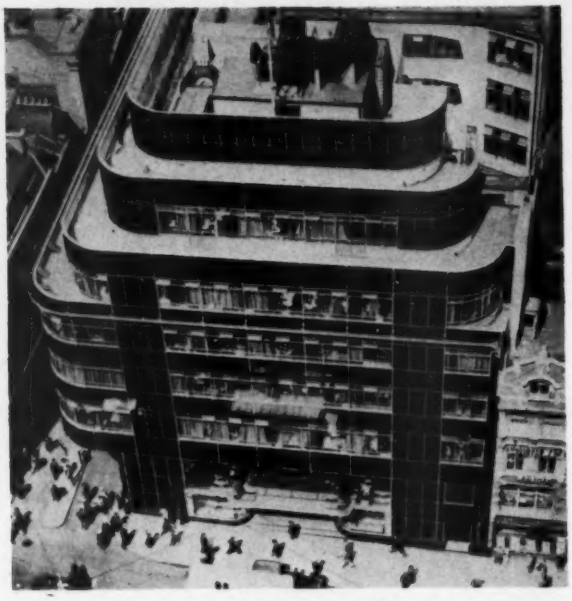
However, safety glass is not the only means by which the glass industry is opening new markets. The advent of air conditioning is making double glazing a necessity. And while storm sash are today acceptable for this purpose, research laboratories are seeking to develop even better products to meet these new and exacting requirements. In the past few years, the skillful use of larger glass surfaces in architectural design have increased tremendously and many new effects with corner windows, picture windows, and many ways of using glass for decorative purposes have been developed. Mirrors are used to brighten dark corners, and women are protecting their furniture with mirrored or plain glass tops.

These developments have not taken place of themselves, Mr. MacNichol concluded, but are the result of aggressive effort on the part of the research and manufacturing departments of the various companies.

CERAMISTS TO BROADCAST TALKS

A group of men prominent in the ceramic industry will give short talks during the week before the American Ceramic Convention at Buffalo to be broadcast by various stations. The first is to be given by L. E. Barringer, General Electric Co., Schenectady, N. Y., on February 5 through station WFBL, Syracuse, at 10:30 P. M., E. S. T. Others will be made by Harold S. Nash, University of Cincinnati, on February 6 over station WKRC, Cincinnati, at 5:15 P. M.; by Dean M. E. Holmes, Alfred University, Alfred, N. Y., on February 7 over station WHAM, Rochester, at 4:45 P. M.; by A. C. Dutton, Titanium Company, Niagara Falls, N. Y. on February 8 over station WKBW, Buffalo, at 8:05 P. M.; by Dr. Alexander Silverman, University of Pittsburgh, Pittsburgh, Pa., on February 15 over station WHAS, Pittsburgh, at 5:00 P. M.

The Chicago office of Kirk & Blum Mfg. Co., Cincinnati, has been removed from 407 South Dearborn Street to 3843 N. Central Park Ave.



This glass house is the home of the London Daily Express in Fleet Street. Rounded corners and black glass frontage resemble the promenade deck of a luxury liner.

NEW COMPANY FORMED TO MANUFACTURE REFRACTITE

A new company, the Industrial Refractories Corporation, Pittsburgh, Pa., recently has been formed to handle sales, research and engineering consultation on a new process of glass-tank construction that departs radically from the methods of construction long in vogue. The new process hinges on the use of "Refractite," a recently developed impregnating material that processes high refractory powers, and imparts distinctly unusual qualities to glass tanks built with its use.

"Refractite" was developed by Chemical Refractories, Inc., Pittsburgh, Pa., and initially called "Refracto." Glass-men will recall the announcement of its advent last year. The term "Refractite" has been selected since as more completely descriptive of the action and functions of the material when in use, and patent application has been made for it under that name.

Following the initial announcement, the sponsors of this product have maintained a side-line position to await service reports from a number of installations. After more than a year's service in the production of plain, crystal and colored glass, many outstanding advantages from the standpoint of cost reduction have been observed.

The method of tank construction in the Refractite process is as follows: Power-pressed fire-clay bricks such as Harbison-Walker "Benezet" or equal, are used throughout in place of the customary flux block and silica brick combination. The bricks are first soaked thoroughly in water, then dipped in "Refractite" of the proper consistency and laid at once, without the use of any cement or bond. The buck-stays are pulled up tight, and the tank fired full blast immediately. The curing process is completed within 24 hours instead of the approximate week required with old-style methods. The first melt is worked at once thereafter, reducing production lost-time to a minimum, and effecting extensive savings in construction time and cost, and in gas burned during curing.

The buck-stays need not be loosened while curing, as there is no appreciable expansion of the brick while heating. Likewise, there is little or no contraction in cooling. The glass-plants using Refractite tanks are able to let out their tanks stone-cold at any time, and re-fire full blast at will without injury of any sort to the tank. The fuel economy thus secured is enhanced by the observed fact that heat loss through a Refractite tank wall is far below that of the old style tank, producing considerable reduction in melting time, in some cases as much as six hours.

Coincidentally, the workable glass per melt is increased because the Refractite-impregnated brick shows much less tendency to spall off. It is customary to work the new tanks to the bottom, with good glass all the way down. Altho the plants currently using Refractite-processed glass tanks do not manufacture every type of glass on the market, their output includes a sufficient variety of plain, crystal and color glasses to draw the conclusion that Refractite tanks are equally efficient, irrespective of the glass being worked. The corrosive constituents in opal glass, for example, exert no untoward effect on them.

Tank life has proved to be equivalent to that of the old-style construction, but here again the Refractite process shows an advantage. If necessary, Refractite-processed tanks can be repaired during a let-down period, at much less cost than complete replacement. Bricks are simply taken out and replaced with new, with very little loss of time and no danger of injury to the tank from the cooling and subsequent refiring.

PRODUCTION SCHEDULES INCREASED

About 1200 men were added by the Libbey-Owens-Ford Co., Toledo, O., manufacturer of safety glass and sheet glass products, when their production schedules were increased in December. The enlarged basis is expected to continue for an indefinite period. The increase is due to automobile manufacturers' requirements, together with other sizeable orders now in sight. The business from automobile makers now represents about 65 per cent of the total as compared with 40 per cent a year ago.

SILICA SAND COMPANY ORGANIZED

The Hutchins Silica Sand & Clay Co., recently was formed at Kane, Pa., to construct and operate a silica plant at Hutchins, Pa. The new company will take over property at Hutchins formerly used by a concern of a similar name whose plant was destroyed by fire involving a loss of over $40,000. It is proposed by the new company to rebuild this plant at an early date and install new equipment for extensive production. Plans are now progressing to this end. Joseph Gaffney and R. A. Hill, Jr., Kane, head the organization.

GLASS PLANT TO REBUILD

The West Virginia Glass Specialty Co., Weston, W. Va., manufacturer of stemware, tumblers and kindred glass products, is said to be planning to rebuild a portion of the plant destroyed by fire, on January 1, with a loss of close to $100,000.

TURNER OFFERS DOMESTIC K_2CO_3 SPECIALLY FOR GLASS MAKING

Realizing the need for a domestic source of supply, Joseph Turner & Company of New York City are offering Carbonate of Potash manufactured in the United States.

The material has been especially prepared for the glass industry in uniform crystals testing 83/85% K_2CO_3 and is the result of several years research. Instead of bulky hard to handle casks, the Carbonate is being packed in even weight barrels of 400 pounds net, thus facilitating handling. The K_2CO_3 is produced at Niagara Falls, N. Y. and shipments have already been made in carlots to glass manufacturers.

C. N. MUESSIG RETIRES FROM DRAKENFELD

C. Nick Muessig, retired from B. F. Drakenfeld & Co., Inc., 45 Park Ave., New York, on January 1 after nearly 52 years of association with the firm, although still enjoying ordinary good health. When the Company's branch office was opened in 1901 at East Liverpool, Ohio, he was made manager of that branch. Ten years later he was transferred to the New York office where he remained until 1914, returning to East Liverpool at that time. He was recalled to the New York office in 1922 where he remained until his retirement.

WOLF-BLITZ CHANGES NAME

The company formerly known as the Wolf-Blitz Glass Company changed its name at the beginning of the year to the Louisville Plate Glass Company, Inc. It is located at the corner of Broadway and Fourteenth Street, Louisville, Ky. There will be no change in the Company's personnel, a recent announcement states.

WILLIAM H. ELKINS DIES

Just after the January issue had gone to press the sad news was received of the death of William H. Elkins, vice president of the Overmyer Mould Company, as the result of an automobile accident on New Year's day. Active in the glass business through practically his whole life THE GLASS INDUSTRY marks the passing of one of the industry's foremost members and extends sympathy to Mr. Elkins' many friends and associates in their bereavement.

GENERAL REFRACTORIES APPOINTS SYRACUSE, YORK AGENT

General Refractories Co., Philadelphia, Pa., announces the appointment of the Patton Clay Manufacturing Co., Syracuse, N. Y., as dealer-agents in the Syracuse area. This company will carry a complete stock of refractories in addition to its well rounded line of building supplies. George F. Motter's Sons Supply Co., York, Pa., has been appointed dealer-agents in the York area and will add a complete stock of refractories to its full line of mill supplies.

PAID $2,000,000 IN WAGES IN 1934

During 1934 the Clarksburg plant of the Hazel-Atlas Glass Co., paid $2,000,000 in wages to its employees, Karl Weaver, superintendent, recently declared in an address before the Clarksburg Kiwanians. He said that at the peak of the year there were 2,500 people employed and that early in December there were 1,500. The employment varied with the demand for ware and also with the particular kinds of ware in demand. The plant produced during the year 240,000,000 pieces of glassware, or about two pieces for every man, woman and child in the country.

A view from the air of the new home of the Lynch Corporation, Anderson, Ind. This was once a busy industrial center. In the foreground (extreme right) was the Ross Supply Co; to the left just beyond the tree clump was the Victor Window Glass Co; left of the crossroads at the center near the top of the picture was the Anderson Glass Co; almost directly above the Lynch office on the next street was the National Tin Plate Co; across the road the American Window Glass Co. Photo by Frank Preston.

EQUIPMENT AND SUPPLIES

HILGER VIEWER MEASURES THICKNESS

An instrument for measuring the thickness of glass sheet, plate, blown glassware, tubes, etc., which has the advantage of working from one side of the material only is the Hilger Glass Thickness Viewer. It enables the material to be measured during manufacture or when fitted. This makes it possible to examine articles immediately after they are blown and to determine the average thickness of the walls. Also it is possible to search for local variations which might involve dangerous strains. Such variations may occur, for example, in the large bulbs used in radio transmitting tubes which may lead to breakage in use, involving serious inconvenience.

The article is applied to an orifice at one end of the instrument and the measurement is determined by observing the length of scale between two lines at the other end. In the case of large glassware it may be more convenient to take the Hilger Viewer to the work. If so it may easily be removed from its stand by undoing a single screw.

INTRODUCE "NUMERALS IN COLORS" FOR MULTIPLE-POINT RECORDING

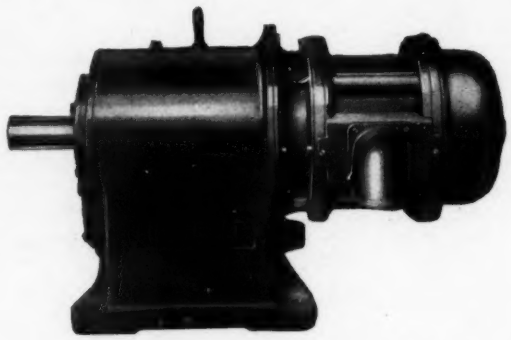
Reading of multiple-point instrument records is greatly simplified by a new system of "numerals in colors" introduced by Leeds & Northrup Company, Philadelphia. This marking system can be specified on Micromax strip-chart recorders for 2, 3, 4 or 6 points. With each of the thermocouples, resistance thermometer bulbs or other primary elements identified on the chart by a numeral, and each numeral distinguished from the others by being printed in a contrasting color, reading

of records is made easy, errors are avoided and time is saved. Colors used for printing and numerals are: black, green, red, violet, yellow and blue. The print-wheel on these Micromax Multiple-Point Recorders has a separate inking pad for each point to be recorded.

MOTORIZED REDUCERS INTRODUCED

In order to meet the growing demand for still greater compactness and economy in self-contained enclosed speed reducing units, Link-Belt Company, Philadelphia, is placing on the market a new line of Motorized Helical-Gear Reducers, an outstanding feature of which is the unusual accessibility of the motor and the high speed gears.

A standard round-frame motor is secured firmly to side of reducer housing by means of an adapter cast-



ing which supports the motor shaft. The complete motor, with adapter and motor pinion, may be removed as a unit for inspection or maintenance, without disturbing the alignment of the motor, or of the gears remaining in the reducer housing. The motor pinion and gear also are removable without disconnecting the driven machine or disturbing the low speed gears. Anti-friction bearings are used throughout. The low speed shaft and its bearings are designed to carry heavy loads.

GLASS SILK A DISPLAY MATERIAL

As fine as the finest white hair is the sample of "glass silk," spun glass, received from Friedrich & Dimmock, Millville, N. J., with sales offices at 7 East 42nd Street, New York. This crimped material is pure white and fireproof and has recently been placed on the market as a display material. This firm has been manufacturing glass wool (spun glass) at their Millville plant since 1922 and large quantities have been used for filtering chemicals, air filters, storage battery separators, etc. This new material which is manufactured in bolts 18 inches wide and 18 feet long is meeting with approval wherever shown. However, there is always that note of wonderment and incredulousness at the idea that the material is really glass.

LACLEDE SPALLAC ANNOUNCED

The Laclede-Christy Products Co., St. Louis, Mo. announce that the new name of Laclede Spallac has been given to their well known fire brick formerly known as Laclede Mullite. The firm emphasizes in the announcement that only the name is being changed and the product will continue the same high grade refractory that it has been since its introduction early in 1932.

GLASS MOULD EXPERT ACTIVE IN AMERICAN FOUNDRYMEN'S ASSOCIATION

R. L. Binney, president of The Binney Castings Company of Toledo, Ohio, manufacturers of glass moulds exclusively, attended the recent convention of the American Foundrymen's Association in Philadelphia.

Mr. Binney holds the important position of Chairman of the Program and Papers Committee. This committee functions the year round and passes on articles for publication in the Association's magazine.

We are informed by Mr. Binney that there has been an immense amount of work performed by foundrymen over the country, experimenting with alloys for glass moulds.

In this respect Mr. Binney cites the symposium on the Deoxidation and Degasification of Non-Ferrous Alloys, which has been under way for several years. Mr. Binney was Chairman of the Division having the symposia.

Inasmuch as deoxidation and degasification of alloys in moulds formed one of the stumbling blocks to the successful production of glass moulds, our industry owes thanks to the Foundrymen's Association for the vast amount of practical and scientific knowledge they have assembled. This knowledge being so necessary to cast moulds from complex alloys.

While it is a tribute to Mr. Binney's skill and standing that he should hold such important chairmanships in the American Foundrymen's Association, it is also flattering to our industry that a metallurgist who has devoted his time and his company's interest exclusively to the manufacture of alloys for glass moulds should be so honored.

O. HOMMEL CO. ADDS TO SALES STAFF

Frank L. Campbell was recently appointed General Sales Manager of The O. Hommel Company, Pittsburgh, Pa. Mr. Campbell comes to The O. Hommel Company with extensive sales and business experience. He was formerly sales manager of John Lucas & Co., Chicago, Ill., sales manager of The Beaver Board Companies, Buffalo, N. Y., general sales manager, U. S. Chain & Forging Company (now The McKay Company), Pittsburgh, Pa., manager, Congoleum-Nairn Co., Chicago, Ill., and more recently, sales manager of the Masonite Corp., Chicago, Ill. L. L. Heinz also recently joined the Sales Staff of The O. Hommel Company.

CATALOGS RECEIVED

The Chapman Water Jacketed Gas Producer issued by the Cooper-Bessemer Corporation, Mt. Vernon, Ohio. This construction is employed to eliminate the adhesion of clinkers to the producer walls in turn resulting in a number of other advantages.

Aftercoolers for Air or Gas, by Ingersoll-Rand, New York. The aftercooler removes moisture from compressed air or gas after leaving the compressor and before it enters the distribution system eliminating thereby a number of difficulties.

Dark Field Optical Systems issued by Bausch & Lomb, Rochester, N. Y., covering microscope accessories for this field of work.

What About Your Roof? and *J-M Insulated Roof and Holorib Steel Deck* by Johns-Mansville, New York.

YALE & TOWNE DESIGNS TAMPER PROOF BOTTLE

A Yale locked liquor bottle is now being offered to first class bottle manufacturers who are technically equipped to produce a bottle of such characteristics. It was designed by the Yale and Towne Manufacturing Co. who for nearly three-quarters of a century have made their business that of protection. The bottle is so formed as to preclude any tampering with its contents between the bottler and his customer.

When the bottle is filled at the bottling plant, a stopper is inserted down in the neck and the top of the bottle is hermetically sealed, forming a chamber which is a part of the bottle and actually encloses it in this sealed space. There is only one way to uncork the bottle and that is to sever and remove the sealed chamber from the top of the neck, exposing the stopper. This is done by inserting the tip of the Yale key in a notch in the bottle neck and turning it so the pressure snaps off the top of the neck. In this way the bottle is put out of commission and cannot be used for further repackaging.

After the Yale bottle is unlocked and the top thrown away the liquor remains corked until the porcelain stopper is pulled out. The severed portion of the bottle neck is covered snugly and safely by an elastic collar which snaps into place the instant the bottle is unlocked. The locking feature of the bottle applies only to the neck and may be used on any standard design of bottle. Regardless of the shape of the bottle body the Yale neck will be distinctive so that it may readily be identified by the prospective purchaser. It will prevent the bootlegger from imitating the packages of well known brands. The use of this protective measure will not increase the price of the liquor as the Yale locking parts are simple and inexpensive. The quality of the liquor will be guaranteed by the distiller filling the bottle. The genuineness of the liquor will be assured by the Yale locked top.

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

		Carlots	Less Carlots
Acid			
Citric (dom.)	lb.	...	.29
Hydrochloric (HCl) 20° tanks	Per 100 lb.	...	1.10
Hydrofluoric (HF) 60% (lead carboy)	lb.	...	.13½
52% and 48%	lb.	.10	.10-.11½
Nitric (HNO_3) 130 lb. carboy ext.	Per 100 lb.	5.50	...
Sulphuric (H_2SO_4) 66° tank cars	ton	15.50	...
Tartaric	lb.	...	Po. or Gr. .25 / Cry. .25½
Alcohol, denatured	gal.	...	...
Aluminum hydrate ($Al(OH)_3$)	lb.	.04-.04½	.04½-.05
Aluminum oxide (Al_2O_3)	lb.	.04	.05
Ammonium bicarbonate (f.o.b. works)	lb.	.05¼	...
(f.o.b. N. Y.)	lb.	...	.0571
Ammonium bifluoride (NH_4FHF)	lb.	...	.15
Ammonium nitrate (NH_4NO_3)	lb.	...	.08
Ammonia water (NH_4OH) 26° drums	lb.	...	.02¾
Antimonate of Sodium	lb.	...	.10½
Antimony oxide (Sb_2O_3)	lb.	...	.11¼
Antimony sulphide (Sb_2S_3)	lb.	...	.11
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03½	.04-.04½
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	40.00	45.00
90% through 100 mesh	ton	37.00	...
Barium hydrate ($Ba(OH)_2$)	lb.	.05	.05½
Barium nitrate ($Ba(NO_3)_2$)	lb.	...	.08
Barium selenite ($BaSeO_3$)	lb.	...	1.50-1.75
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Bone ash	lb.	.06	.06½
Borax ($Na_2B_4O_7 10H_2O$)	lb.	...	...
Granulated	In bags, lb.	.02	.02¼-.02½
Powdered	In bags, lb.	.02¼	.02½-.02¾
Boric acid (H_3BO_3) granulated	In bags, lb.	.04¼	.04½-.04¾
Cadmium sulphide (CdS)—	lb.	...	.70-.75
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Chromite	lb.	...	.0215
Cerium hydrate 100 lb. drums and 600 lb. barrels	lb.	...	.65
Chrome Oxide Green, 400 lb. bbls.	lb.	...	.215-.25
Cobalt oxide (Co_3O_4)			
In bbls.	lb	...	1.25
In 10 lb. tins	lb.	...	1.35
Copper oxide			
Red (Cu_2O)	lb.	...	.25
Black (CuO)	lb.	...	.17-.19
Black prepared	lb.	...	.22
Cryolite ($Na_3Al F_6$) Natural Greenland (Kryolith)	lb.	.08½	.09
Synthetic (Artificial)	lb.	.08	.08½-.09
Epsom salts ($MgSO_4$) (imported) technical	Per 100 lb.	...	2.30
Feldspar—			
20 mesh	ton	10.00-12.25	
40 mesh	ton	10.50-12.75	
Granular	ton	10.75-13.00	
Semi-granular	ton	10.00-12.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%)			
Bulk, carloads, f. o. b. mines	ton	25.23	...
In bags	ton	26.83	38.00-40.60
Formaldehyde, bbls.	lb.	...	.07
Graphite (C)	lb.	...	.04-.07
Iron oxide—			
Red (Fe_2O_3)	lb.	...	.0425
Black ($Fe3O_4$)	lb.	.04½	..
Iron chromate	lb.	...	.035-.05
Kaolin (f. o. b. mine)	ton	8.00-9.00	..
English, lump, f. o. b. New York	ton	14.50-25.00	24.50-30.00
Kryolith (see Cryolite)			
Lead chromate ($PbCrO_4$)	lb.	...	.16
Lead oxide (Pb_3O_4) (red lead)	lb.	.062	...
In 5 Ton lots	lb.	...	.063
Less than 5 Tons	lb.	...	.07
Litharge (PbO)	lb.	.052	...
In 5 Ton lots	lb.	...	.055
Less than 5 Tons	lb.	...	.06
Lime—			
Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	10.50	...
Burnt (CaO) ground, in bulk	ton	7.00	...
Burnt, ground, in paper sacks	ton	9.00	...
Burnt, ground, in 280 lb. bbls.	Per bbl.	2.25	2.25
Limestone ($CaCO_3$)	ton	1.75-2.50	...
Magnesium carbonate ($MgCO_3$)	lb.	.06	.08-.09
Magnesium sulphate (U.S.P.)	lb.	...	.03
Manganese, Black Oxide			
In Paper bags	ton	45.00	50.00
In Burlap bags	ton	46.50	51.50
In Casks	ton	48.00	53.00
Neodymidm oxalate, 50 lb. drums	lb.	...	5.00
Nickel oxide (Ni_2O_3), black	lb.	...	.35-.40
Nickel monoxide (NiO), green	lb.	...	.35-.40
Plaster of Paris, bags	ton	31.00	23.00-29.00
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals	lb.	...	.08¾
Powdered	lb.	...	.09¾
Potassium carbonate	lb.	.0825	.0875
Calcined (K_2CO_3) 96-98%	lb.	.07¾	.0875
Hydrated 80-85%	lb.	.06½	.0687
Potassium chromate (K_2CrO_4) 450 lb. bbls.	lb.	...	.16
Potassium hydrate (KOH) (caustic potash)	lb.	.06¼-.06½	.08-.08½
Potassium nitrate (KNO_3) (gran.)	lb.	...	.06-.06¼
Potassium permanganate ($KMnO_4$)	lb.	...	.19
Powder blue	lb.	...	.17-.18
Rare earth hydrate			
100 lb. drums	lb.	...	.35
325 lb. barrels	lb.	...	.30
Rochelle salts, bbls.	lb.	...	.12½
Rouge	lb.	...	Po. or Gr. .13½ / Cry.
Rutile (TiO_2) powdered, 95%	lb.	.15-.20	.20-.25
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	27.00
Selenium (Se)	lb.	...	2.00-2.10
Silver nitrate ($AgNO_3$) . (100 oz. bot.)	per oz.	...	.40
Soda ash (Na_2CO_3) dense, 58%—			
Bulk	Flat Per 100 lb.	1.10	...
In barrels	Per 100 lb.	1.50	...
In bags	Per 100 lb.	1.25	...
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06½	.06¾
Sodium chromate ($Na_2CrO_4 10H_2O$)	lb.	...	.08
Sodium fluosilicate (Na_2SiF_6)	lb.	.04¾	.05¼
Sodium hydrate (NaOH) (caustic soda)			
Flake	Per 100 lb.	3.00	...
Solid	Per 100 lb.	2.60	...
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls.	Per 100 lb.	...	2.00-2.25
95% and 97%			
Bulk	Per 100 lb.	1.175	...
200 lb bags		1.24	1.29
100 lb. bags		1.275	1.325
Sodium selenite (Na_2SeO_3)	lb.	..	1.80-2.00
Sodium uranate (Na_2UO_4) Orange	lb.	..	1.50-1.55
Yellow	lb.	...	1.50-1.55
Sodium uranyl carbonate	lb.	...	.80-.90
Sulphur (S)—			
Flowers, in bbls.	Per 100 lb.	3.35	3.70-4.10
Flowers, in bags	Per 100 lb.	3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls.	Per 100 lb.	2.90	3.25-3.65
Tin chloride ($SnCl_2$) (crystals) . in bbls.	lb.	...	.38
Tin oxide (SnO_2) in bbls.	lb.	...	.54-.58
Uranium oxide (UO_2) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	...	3.00
Yellow orange	lb.	...	1.60
Zinc oxide (ZnO)			
American process, Bags	lb.	.065	.0675
White Seal, 150 lb. bbls.	lb.	.10¾	.10¾
Green Seal bags	lb.	.09¾	.09¾
Red Seal, bags	lb.	.08¾	.08¾
Zircon			
Granular (Milled .005-.02c higher)		.07	.67½-.08
Crude, Gran. (Milled .005-.02c higher)		.03½	.04-.05

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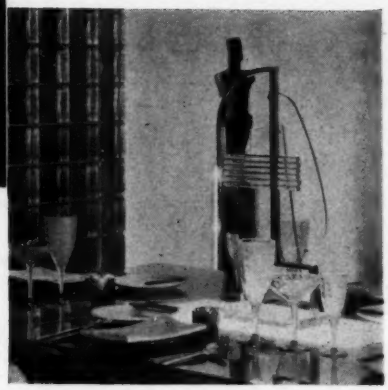

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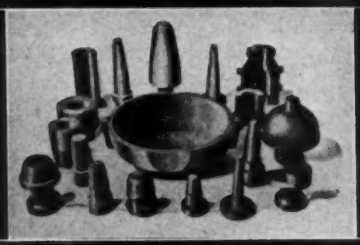

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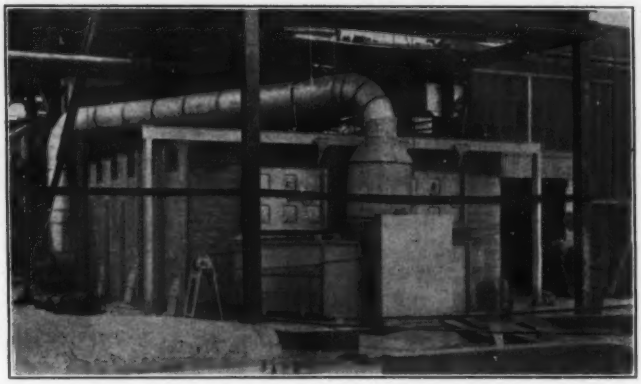

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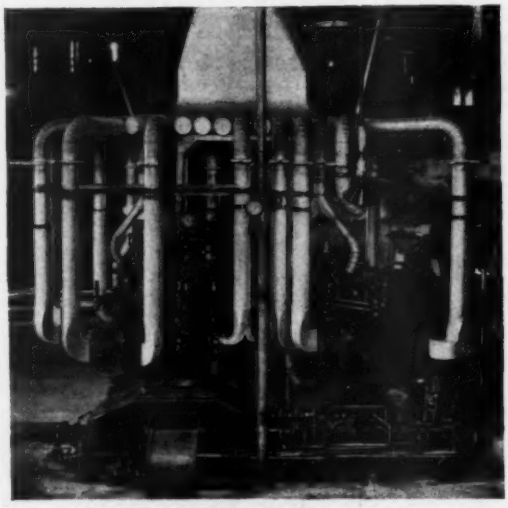

Kirk & Blum improved cooling system on the new No. 10 Lynch Bottle Machine

Advanced engineering principles, careful designing, and installation by skilled erectors—these are the factors in K & B Cooling Systems that reduce power costs and increase production.

Records from installations in many of the larger glass manufacturing plants throughout the country show that because of the savings thus effected, K & B Cooling Systems soon pay for themselves.

Without obligation, our engineers will analyze your cooling problem and recommend where and how savings, if any, may be made. Write

THE KIRK & BLUM MFG. CO.,
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Cincinnati, Ohio

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